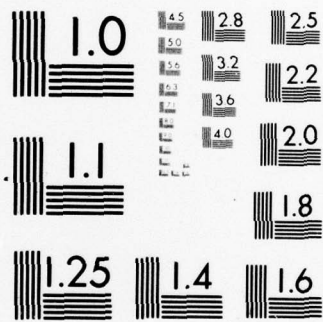


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MEASUREMENTS OF IMPORTANT MINOR CONSTITUENTS IN THE MIDDLE ATMO--ETC(U)
JUN 79 J J OLIVERO DAA629-76-G-0219
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Measurements of Important Minor Constituents
in the Middle Atmosphere

Final Report

John J. Olivero

June 1979

U.S. ARMY RESEARCH OFFICE

U.S. ARO Grants
DAAG29-76-G-0219 and DAAG29-78-G-0083

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University Park, Pennsylvania 16802

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1. Statement of Problem

The project was intended to focus on two separate but related areas of middle atmospheric science. The first was the measurement of middle atmospheric water vapor as a ground based microwave radiometric system designed, developed, and eventually operated at Penn State. The second area was the quantitative, physical and meteorological appraisal of the hypothesis that the mesosphere contains large numbers of small ice particles on average which contribute uniquely to both normal and disturbed D-region ionospheric phenomena. This would require a sophisticated "cloud physics" type model of the particles and their environment.

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2. Summary of important results.

A. Water vapor measurement study.

At the beginning of this project we were completing a comprehensive study of water vapor measurements in the middle atmosphere from elevated platforms (Longbothum, 1976). We immediately began extending the study to ground based microwave radiometry and explored the possibility of performing such a measurement locally. We would need the following major components: a 22 GHz radiometer with sufficient sensitivity and band width to isolate and define the single rotational line of water vapor (at 22.235 GHz); an antenna with solar tracking mount to resolve the solar disk and track it accurately; and a spectrometer or correlator to resolve the line structure with appropriate signal conditioning and data storage facilities. We wanted the added sensitivity of the solar absorption measurement even though it requires the more difficult solar tracking measurement mode, however we also presume that a (passive) atmospheric thermal emission measurement would be routinely made.

It took far longer than we anticipated but we did obtain an 8 foot diameter parabolic dish antenna on a solar tracking (equatorial) mount from the Penn State Radio Astronomy Observatory. It has been moved to an instrument platform at the new Walker (Environment Sciences) Building housing the Department of Meteorology (in which the Principal Investigator maintains both office and laboratory space).

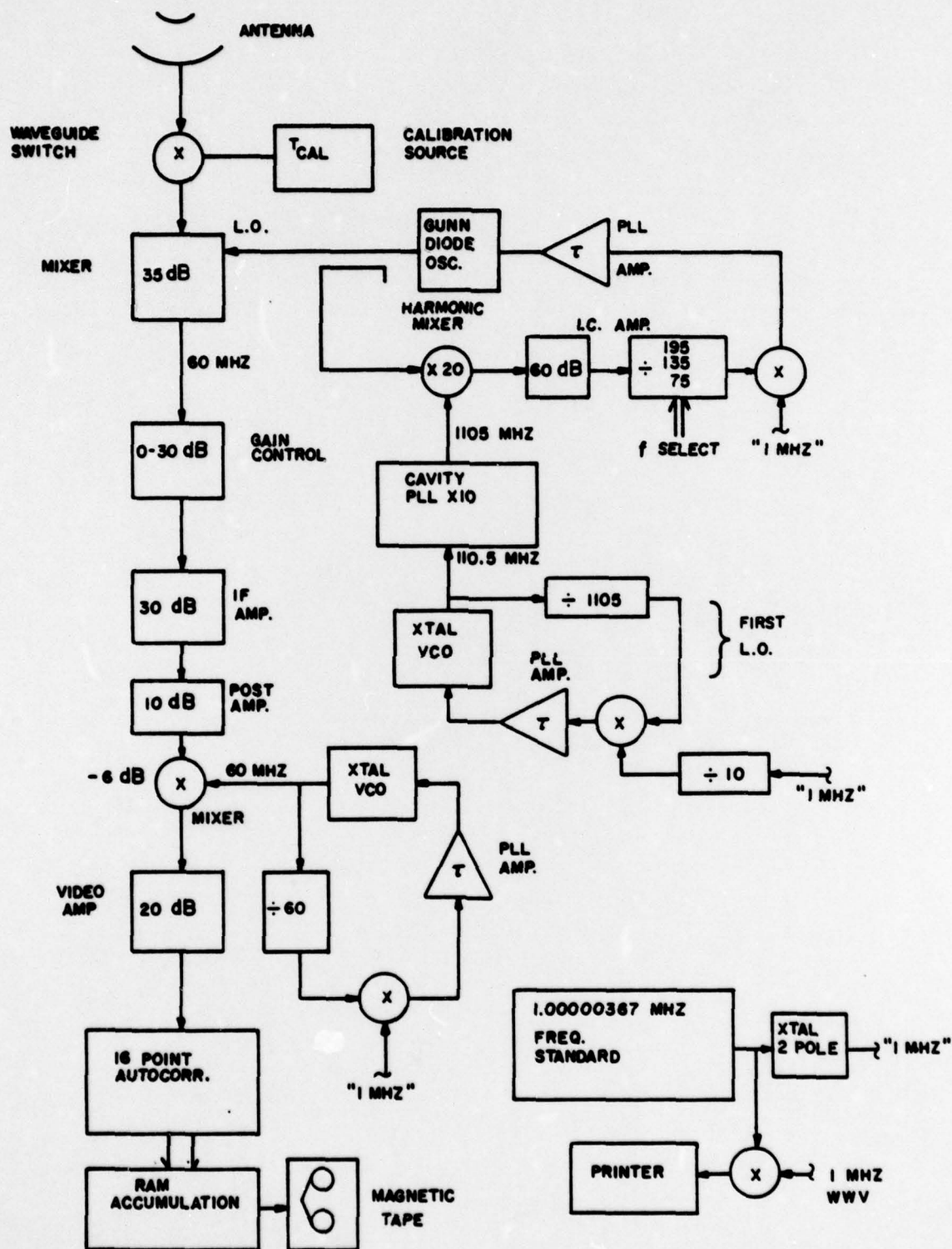
The radiometer has been designed to provide adequate phase and frequency stability ultimately referenced to WWV transmissions (See Figure 1). Components for the radiometer, which is now largely complete, were obtained from university surplus, NASA GFE, as well as through these ARO grants.

In order to obtain vertical profile information from the water vapor rotational line structure, it is necessary to simultaneously observe a number of points on the line ranging from 10s of KHz to 10s of MHz from line center. A special high speed digital autocorrelator was designed, built and tested in a two channel 2X1 bit mode (Petrino, 1978). An expanded, 16 channel, version is nearing completion.

B. Ice particles in the mesosphere study.

Particle layer phenomena at the mesopause have been linked to noctilucent cloud observations and more recently to a polar cap scattering layer. Independent electrical structure measurements in the D-region ionosphere also suggest a particulate ion abundance throughout the mesosphere (Chesworth and Hale, 1974). Moreover, mesospheric particles have been linked to the potential for climatic change (Hummel and Olivero, 1976). For these reasons we have attempted to explore the possibility that small ice spheres might be able to exist as a general constituent of the mesosphere.

We developed a straightforward model of the ice particles surface temperature considering the following energetic processes: molecular, thermal conduction; absorption of solar and terrestrial radiation; radiative (emissive) cooling; and latent heat of sublimation. With time dependent calculations of the heat transfer processes we find that the particles reach quasi-steady state temperatures in the order of seconds and that these temperatures are generally quite different from the ambient environment. From this we determine existence regions which are very complicated functions of particle sizes, ambient temperature, and ambient humidity (Bevilacqua, 1978; Bevilacqua and Olivero, 1979). For reasonable (meteorological) conditions in the mesosphere ice particles will exist much less than a day outside of the "classic" noctilucent cloud-summer polar mesopause existence region. Thus something other than simple ice particles must be responsible for the massive D-region ion phenomena.



3. Publications

Longbothum, Richard L., A Study of Water Vapor Measurement in the Stratosphere and Mesosphere Using Microwave Techniques, Ph.D. Dissertation in Electrical Engineering also Ionosphere Research Laboratory Scientific Report 449 (PSU-IRL-SCI-449), 402 pp, 1976.

Olivero, John J., and R. M. Bevilacqua, Physical Properties Affecting the Existence of Small Ice Particles in the Mesosphere, Space Research, XIX, 165-168, 1979.

Petruno, Patrick, A High Speed Digital Autocorrelator and its Application to Mesospheric Water Vapor Detection, M.S. Thesis in Electrical Engineering, Ionosphere Research Laboratory Scientific Report 458 (PSU-IRL-SCI-458), also submitted to the Atmospheric Sciences Laboratory, WSMR as a technical communication, 113 pp, 1978.

Bevilacqua, Richard M., Ice Particles in the Mesosphere, M.S. Thesis in Meteorology, Ionosphere Research Laboratory Scientific Report 460 (PSU-IRL-SCI-460), also submitted to the Atmospheric Sciences Laboratory, WSMR, as a technical communication, 80 pp, 1978.

Bevilacqua, Richard M. and John J. Olivero, Ice Particles in the Mesosphere, submitted to the Journal of the Atmospheric Sciences, March 1979.

4. Personnel supported by this project and advanced degrees received.

John Olivero, Principal Investigator,
Richard Longbothum, Graduate Assistant,
Richard Bevilacqua, Graduate Assistant,
Patrick Petrino, Graduate Assistant,
Charles Croskey, Research Associate,
David Young, Graduate Assistant.

(Degrees received)

Richard Longbothum, Ph.D. Electrical Engineering
Richard Bevilacqua, M.S. Meteorology
Patrick Petrino, M.S. Electrical Engineering

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- Chesworth, E. T. and L. C. Hale, Ice particulates in the mesosphere, Geophys. Res. Lett., 1, 347-350, 1974.
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- Longbothum, R. M., A study of water vapor measurement in the stratosphere and mesosphere using microwave techniques, Ph.D. dissertation in Electrical Engineering, also Ionosphere Research Laboratory Scientific Report 449 (PSU-IRL-SCI-449), 402 pp., 1976.
- Petrano, P. T., A high speed digital autocorrelator and its application to mesospheric water vapor detection, M.S. thesis in Electrical Engineering, also Ionosphere Research Laboratory Scientific Report 458 (PSU-IRL-SCI-458), 113 pp., 1978.